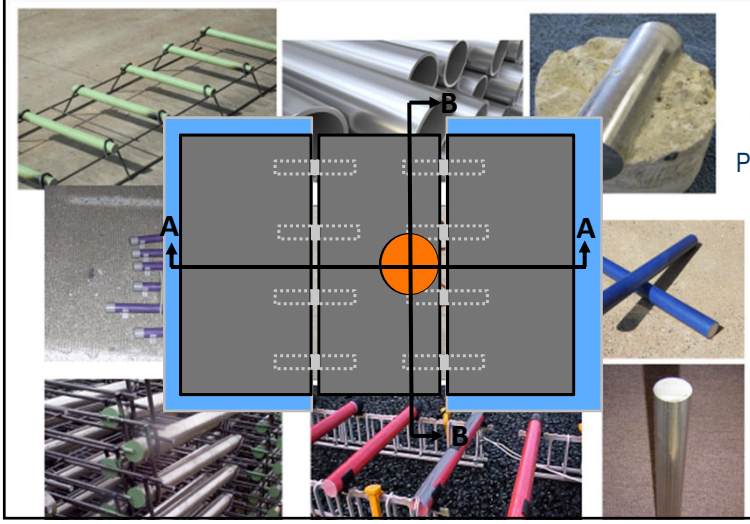
Development of an Improved Protocol for Structural Evaluation of Dowel Load Transfer Systems for Concrete Pavements



Presented by:

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National Concrete Consortium
Spring 2022 Meeting
Nashville, Tennessee
April 6, 2022

Limitations of Current AASHTO Dowel Specs

- Not directly applicable to many dowel products being used and developed today
  - Can't evaluate different dowel materials
    - Different tests needed for different materials, different coatings
  - Can't evaluate behavior of groups of dowels (including effects of nonuniform spacing)

Difficult for manufacturers to innovate.

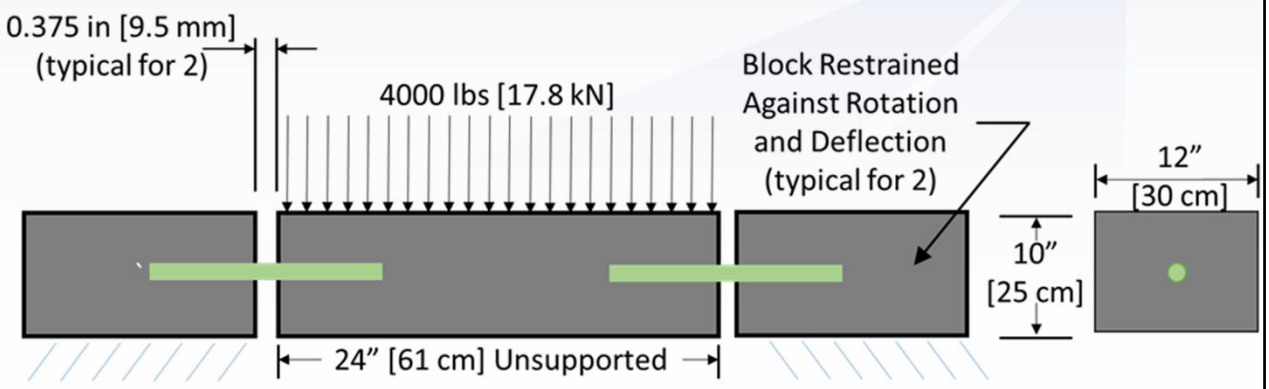
Difficult for agencies to adopt new products.

NCC/ACPA Specification Development

- Original Goals:
  - Develop load-deflection test protocol for dowel groups, and
  - Incorporate protocol in new spec based on AASHTO T253 and M254
- Review and update entire T253 and M254 specs to produce single set of specifications applicable to all current pavement dowel systems
- Specification Development Committee:
  - **Agency Staff**
    - MnDOT - Maria Masten, Rob Golish
    - PennDOT - Neal Fannin
    - MoDOT - Brett Trautman
  - **ACPA**
    - National - Jerry Voigt, Eric Ferrebee
    - WCPA – Kevin McMullen
  - **Dowel Manufacturers/Distributors**
    - AHT/Simplex – Glenn Eder, Mark Kaler
    - Artazn - Mike Mather
    - CMC – Bassam "Ben" Sadawi
    - CRT – Jim Olson
    - MasterDowel – Brad Zaun
    - PNA – Feng Mu
    - O-Dowel - Chris Schenk
    - Owens Corning – Doug Gremel, Bryan Barragan

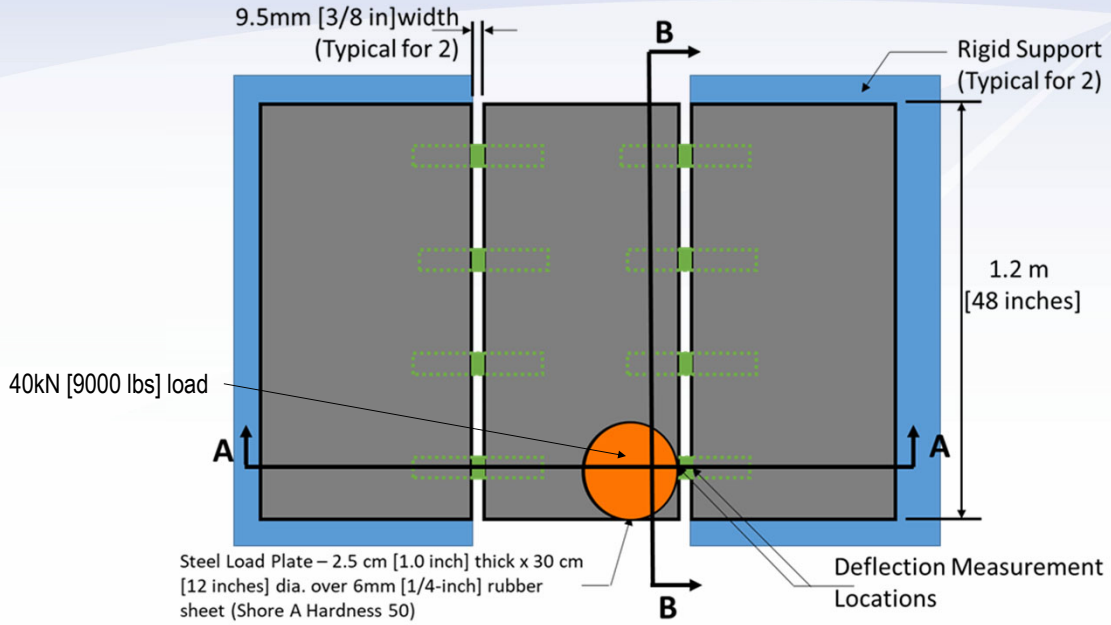
Structural Testing of Dowel *Systems*

Current AASHTO T253 Load-Deflection Test Schematic



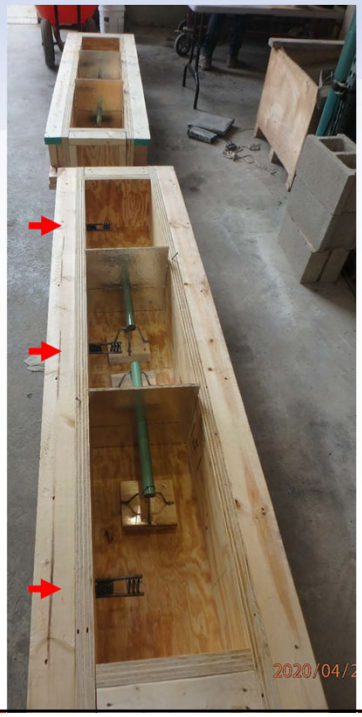
Performance criterion: Limit relative deflection across joints to 10 mils (0.01 inches).

Original NCC/ACPA T253 Load-Deflection Test Schematic

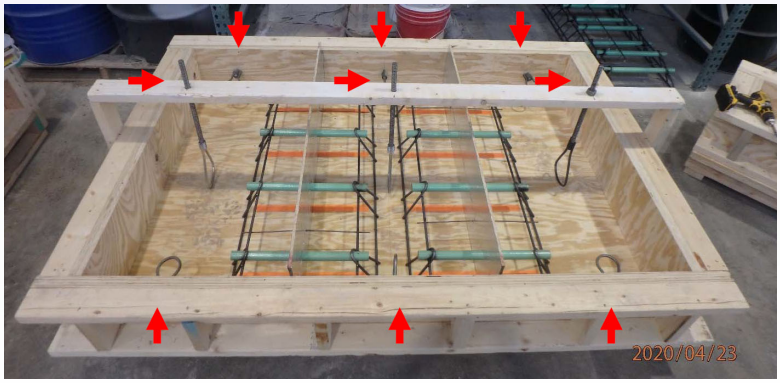


Validation of New Structural Test Protocol (CTL Group Labs May 2020)

- 4 replicates AASHTO T253 load-deflection testing
  - 1.25-inch diameter epoxy-coated steel dowels
  - Yields 8 measurements of relative deflection
- 2 replicates of the proposed modified version of this test
  - Four 1.25-inch diameter epoxy-coated steel dowels per joint
  - *Four test locations per specimen* (one in each of the four corners of the unsupported slab)
  - Yields 8 measurements of relative deflection
- Test protocol modification:
  - Hold load for 10 mins at specified peak (4000 lbs or 9000 lbs), measure RD at start and end of hold
  - Increase load to 150% of specified peak
  - Hold load for 10 mins at new peak (6000 lbs or 13,500 lbs), measure RD at start and end of hold
  - Release load; measure RD at release and 1 minute after release.
- Companion compressive strength/elastic modulus test cylinders



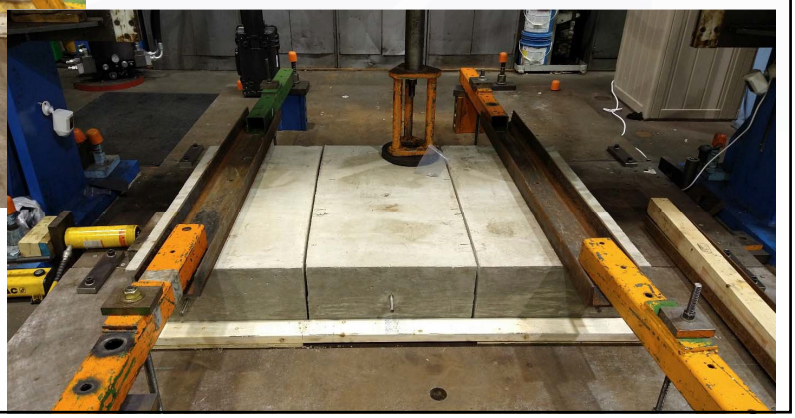
CTL Specimen Moulds with Dowels and Lift Anchors



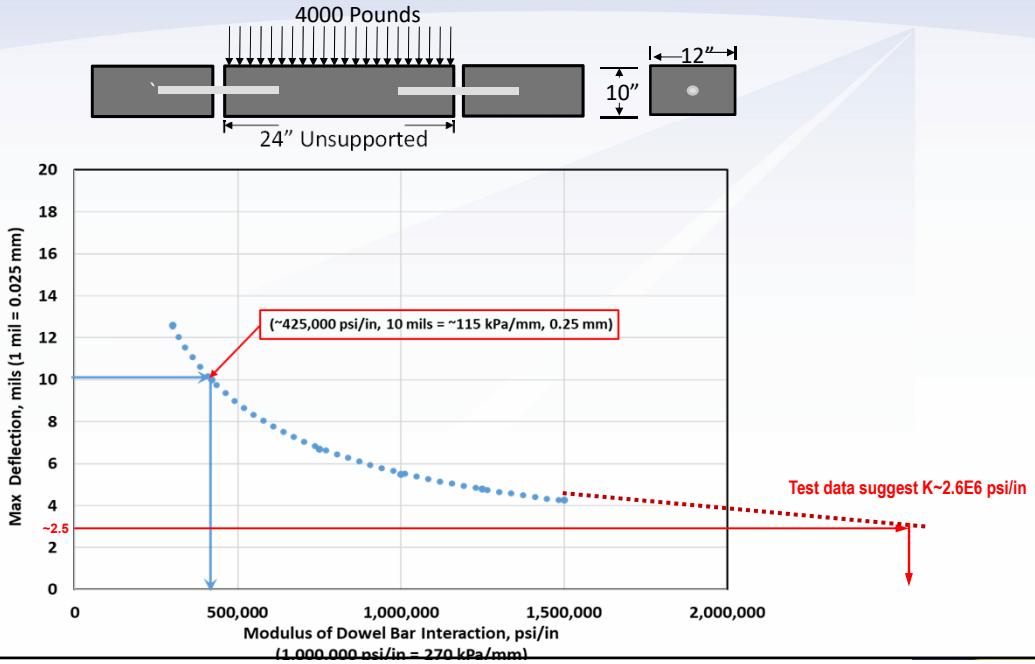
CTL Test Stand Setup (May 2020)

AASHTO T253

ACPA T253



AASHTO T253 Load-Deflection Test Sensitivity to K *(Theoretical)*



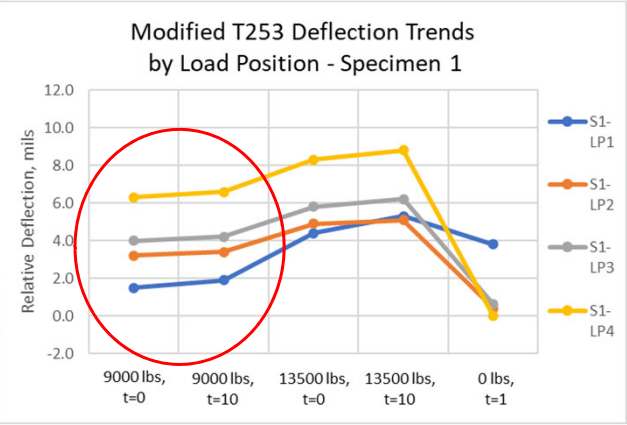
Conclusions and Recommendations

- Original FE models greatly overpredicted dowel deflections
  - Models re-examined – problems were identified and corrected, resulting in much better prediction of observed deflections (average 2.5 mils)

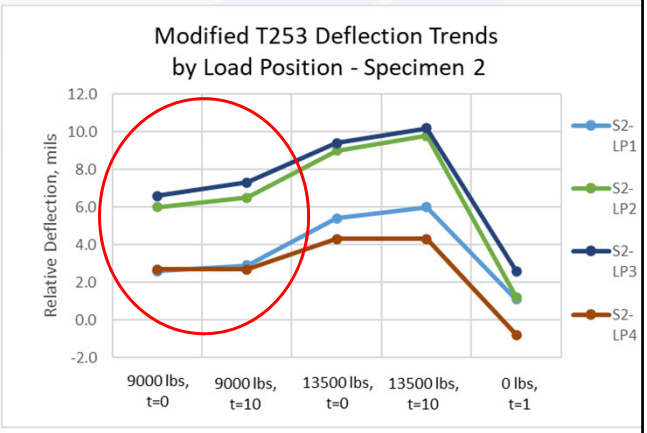
	Relative Deflection, mils	
K (psi/in.)	Updated Model	Original Model
300,000	7.94	16.44
600,000	5.08	9.94
900,000	3.98	7.55
1,200,000	3.37	6.29
1,500,000	2.98	5.51
1,800,000	2.71	4.97

- AASHTO T253 results seem low – possible joint rotation?
  - Reconsider test support conditions (not well-defined in AASHTO spec)

Test Results – ACPA T253 Load-Deflection (with added load and holds)



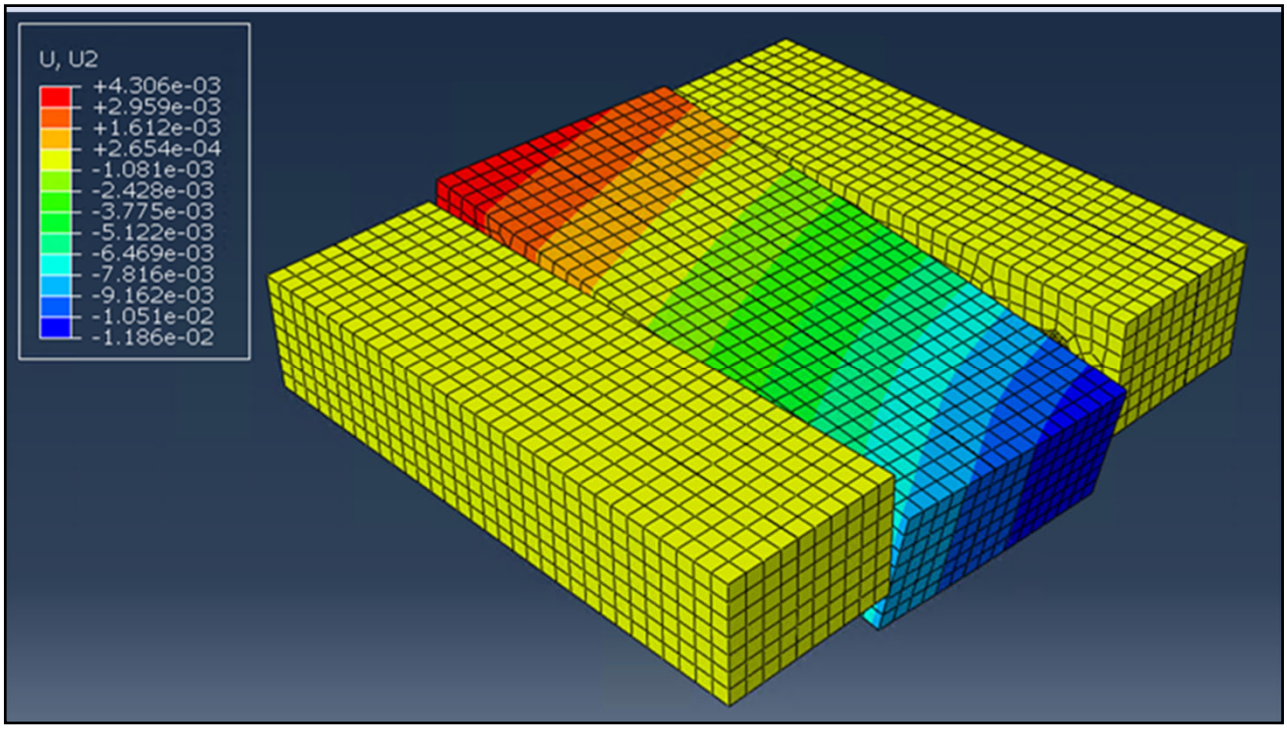
Specimen 1



Specimen 2

Conclusions and Recommendations

- Apparent test sequence bias in ACPA T253 results
  - Moving specimen instead of actuator?
  - Loading protocol (especially overload condition) causing dowel-concrete interface damage?
    - Transferred loads result in excessive bearing stresses
      - **~2160 psi at 4000-lb load, ~3240 psi at 6000-lb load for AASHTO T253 – OK!**
      - **~4000 psi at 9000-lb load, ~6000 psi at 13,500 lb for ACPA T253 – High!**

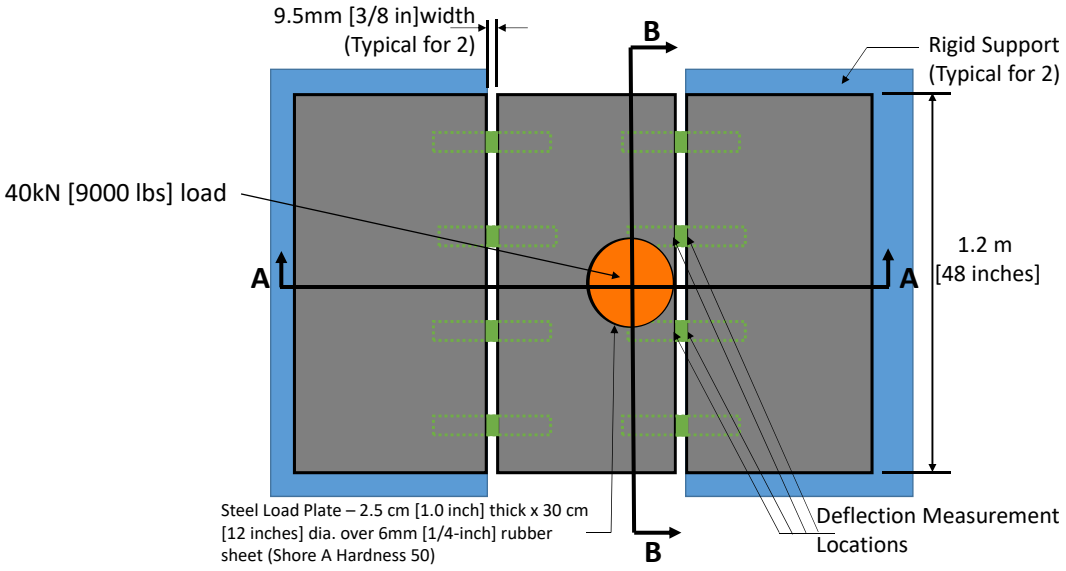


Conclusions and Recommendations

- Apparent test sequence bias in ACPA T253 results (cont.)
  - Loading protocol (especially overload condition) may cause dowel-concrete interface damage.
    - Transferred loads result in excessive bearing stresses
      - **~2160 psi at 4000-lb load, ~3240 psi at 6000-lb load for AASHTO T253 – OK!**
      - **~4000 psi at 9000-lb load, ~6000 psi at 13,500 lb for ACPA T253 – High!**
- Options:
  - 1: Reduce load from 9000 lbs to 4800 lb (creates same shear load in critical dowel as for standard AASHTO T253)
  - 2: Change load from corner to joint center (and change load to match AASHTO T253 shear load?)
    - **Same deflection limit as AASHTO (10 mils) should apply to both options**
  - Either way, change support and move actuator, not specimen!
  - Validate conclusions with additional testing

Revised NCC/ACPA T253 Load-Deflection Test Schematic

(Validation Testing May 2022)

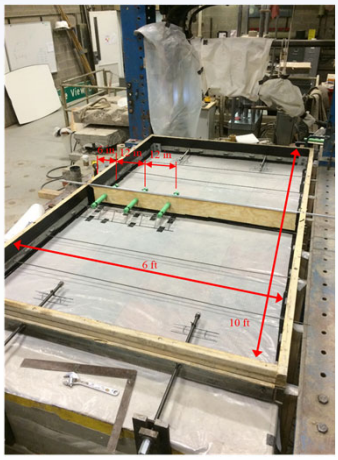


Next Steps

- Additional CTL testing to validate modified structural test protocol (May 2022)
  - NCC-funded testing: AASHTO T253 and Modified T253 tests (1.25-inch and 1.50-inch dowels)
  - Manufacturer-funded testing: 4 manufacturers, at least nine modified test of dowels with various sizes, shapes and materials
- Update ACPA specifications
- Agency "champions" promote new specifications to AASHTO for adoption

Alternate Structural Evaluation Techniques (Agency Option)

- Dynamic load testing (e.g., Pitt ALF)

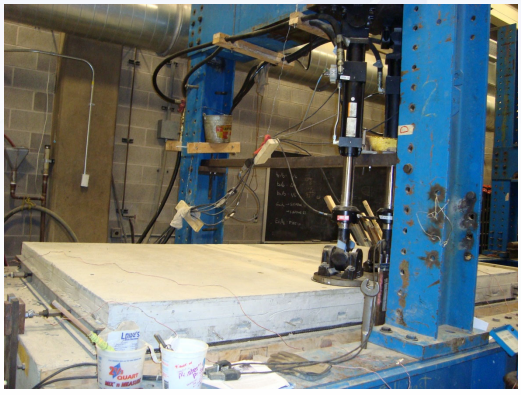


Used as part of dowel acceptance standard by several DOTs

- **PennDOT PTM 642**
- **MnDOT HP Dowel Approval Procedure**

Test:

- **10M Load Cycles**
- **Simulate 9000 lb wheel load**
- **Simulate 45mph vehicle speed**
- **Costly and time-consuming**

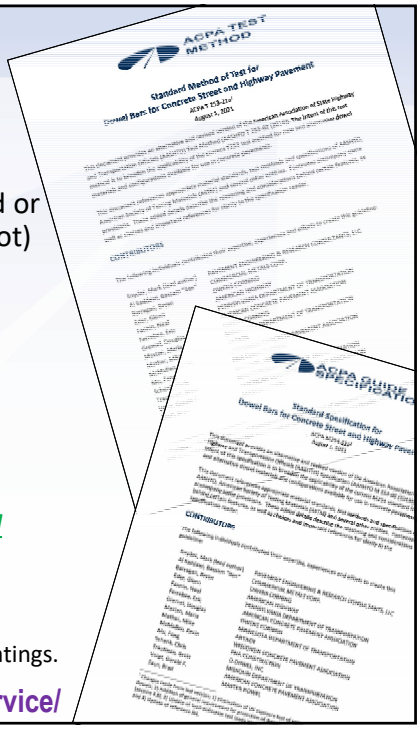


- Analytical evaluation
  - Compute or model shear, bending and bearing stresses

New ACPA "Universal" Dowel Specifications

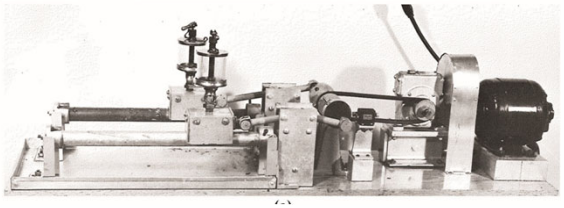
- M 254 – Standard Specification for Dowel Bars for Concrete Pavement
  - Specification developed to address the requirements for manufacture and installation of all types of dowel bars (coated or not, corrosion-resistant or not, cylindrical or not, metallic or not) intended for use in concrete pavements.
  - *Dowels qualified as engineered load transfer systems, not as individual products.*
- T 253 – Standard Method of Test for Dowel Bars for Concrete Pavement
  - Methods to test:
    - Structural behavior of dowel load transfer systems ***using modified protocol***
    - Ability of dowels to withstand the effects of weathering, de-icing chemicals, abrasion and other measures of dowel durability.
      - Suite of applicable durability tests varies with dowel materials and coatings.

Latest specs available at: www.acpa.org/expert-help/technical-service/



Other AASHTO Dowel Spec Tests – Updated and Improved

- Structural Testing
  - Load-Deflection (Static Load, Single Dowel)
  - Pullout
- Durability Testing
  - Abrasion
  - Corrosion
  - Chemical Resistance
  - Cathodic Disbonding
  - Coating Hardness
  - Coating Impact Resistance



Thank You For Your Attention!

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